# Sustainable Energy Systems – SES

## Wind Diesel Workshop

Anchorage, Alaska

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# Background

- In Denmark wind energy penetration in the electric power system is 18% (2004).
- Occasionally wind power penetration is up to 100% in certain regions
- In order to increase the utilisation and value of renewable energy and new technologies it is necessary to strengthen the interaction between energy technologies in the energy system.
- This is a central parameter for development, implementation & market penetration
- On this background Riso has implemented a cross-cutting initiative

**Sustainable Energy Systems - SES**

# Sustainable Energy Systems SES

**A cross cutting initiative between 3 departments**

- Wind Energy
- Energy systems Analysis
- Material Sciences

**Key competencies include**

- Wind turbines & wind energy systems
- Energy systems with high proportions of RE
- Hydrogen & Fuel cells
- Virtual & physical test & experimental facilities

# The “SES project”

Reformation of the energy system within 10 - 30 years

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Risø/SES contributes as centre of research & competences

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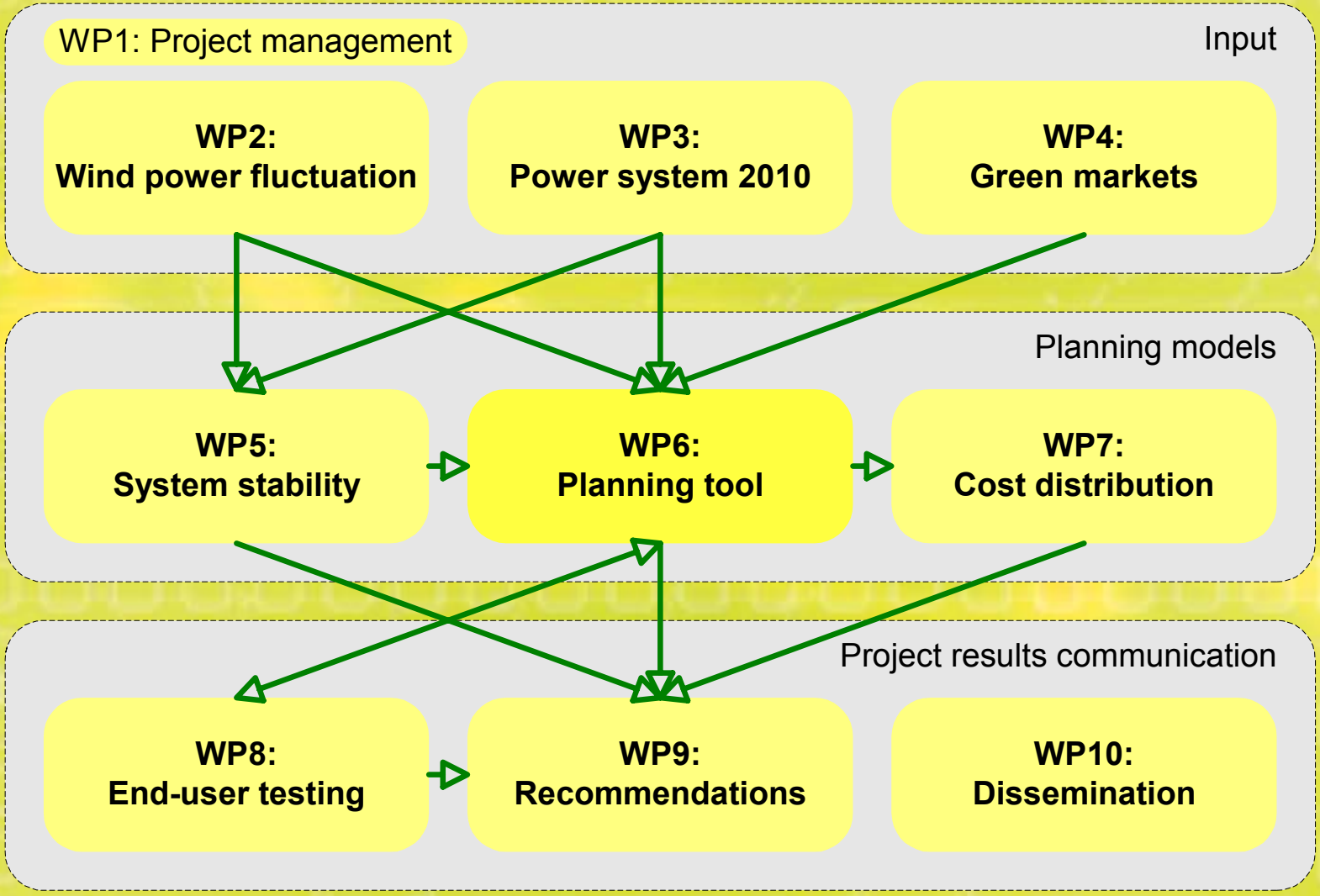
Know-how, methods, simulation, modelling & technology for the sustainable development of the system with increased proportion of RE

- Scenarios & concepts
- Integration of properties, interaction, function & performance of RE systems & components
- Stability, control, regulation, power quality, …
- Interaction with markets, economy, trade, negotiation & implementation of policy instruments, …
- Communication, data acquisition systems, ICT
- Quantification of sustainability & security / safety
- System modules, such as.
  - “Household” module
  - Hybrid systems - village power systems / mini-grids
  - Wind farms with flexible power plant properties
  - Reversible fuel cells
  - Storage systems (vanadium, hydrogen,..)

Experimental verification & characterisation

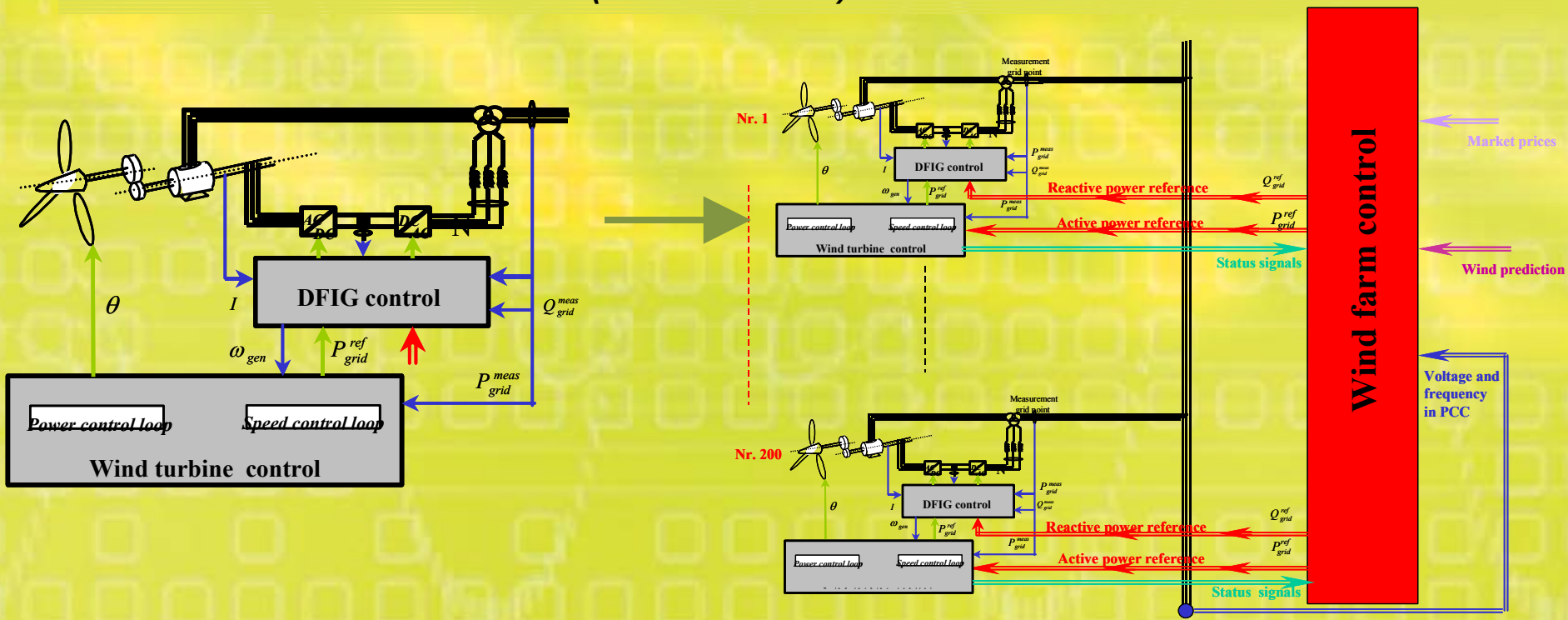
Alliances with the power sector & universities (research consortium, European WE Academy)

# EU WILMAR
# The power market - handling of wind power



# PSO Wind farm Control

- Wind turbine models
  - Active stall (electromechanical to DIgSILENT) - ***Risø(VES)***
  - Doubly fed pitch (electromechanical to DIgSILENT) - ***Risø(VES)***
  - Design load basis (HAWC) – ***Risø(AED)***
- Electrical layout of a wind farm - ***Risø(VES) + AAU***
- Wind conditions in a wind farm - ***IMM+Risø(VES)***
- Wind farm control - ***Risø(AED/VES/ESY)***



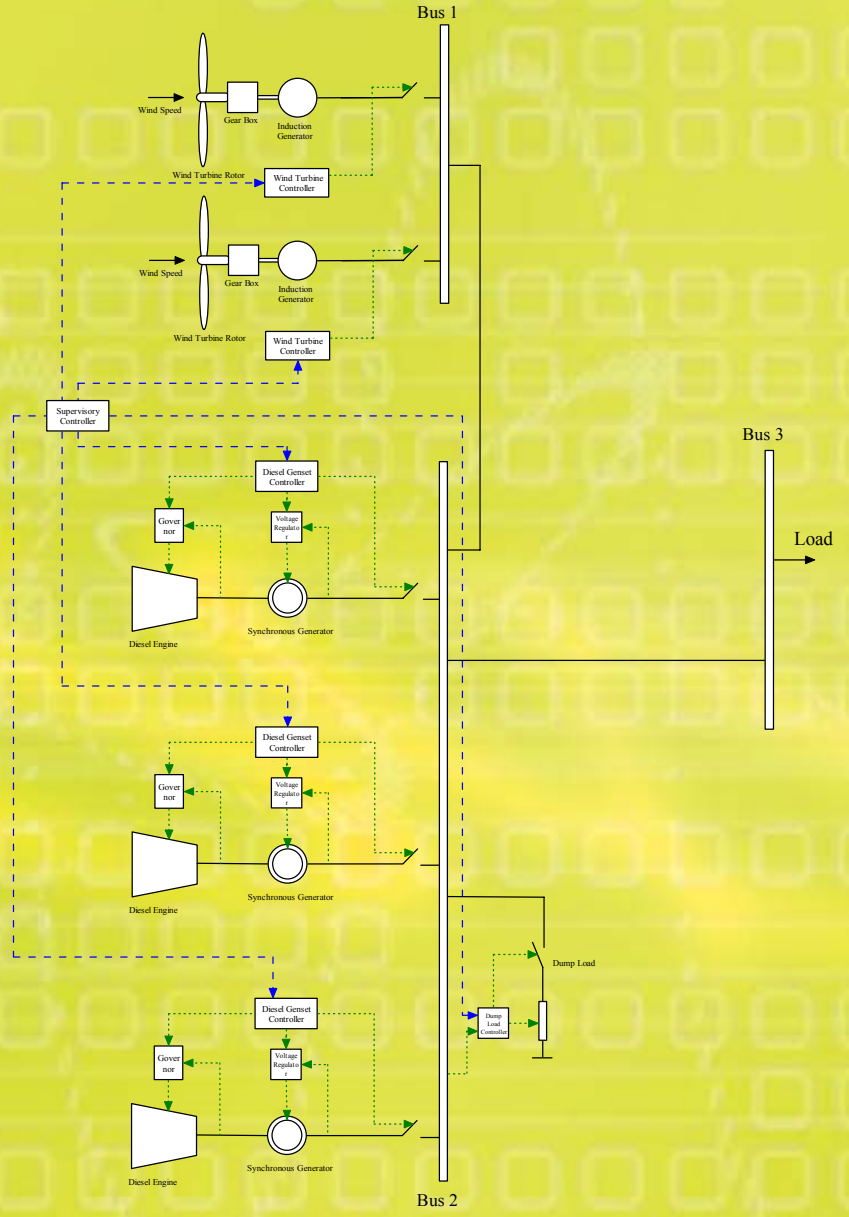
# SES IPSYS

**Simulation of Sustainable Energy Systems - hybrid/minigrid/decentralised/distributed**

- Multiple WT's with different input
- Multiple different generator types
- Storage (batteries, …)
- New components (SOFC, …)
- Multiple busbars
- Electric grid
- Multiple consumers
- Flexible configuration
- Flexible control; centralised / decentralised
- Time scale: seconds to minutes

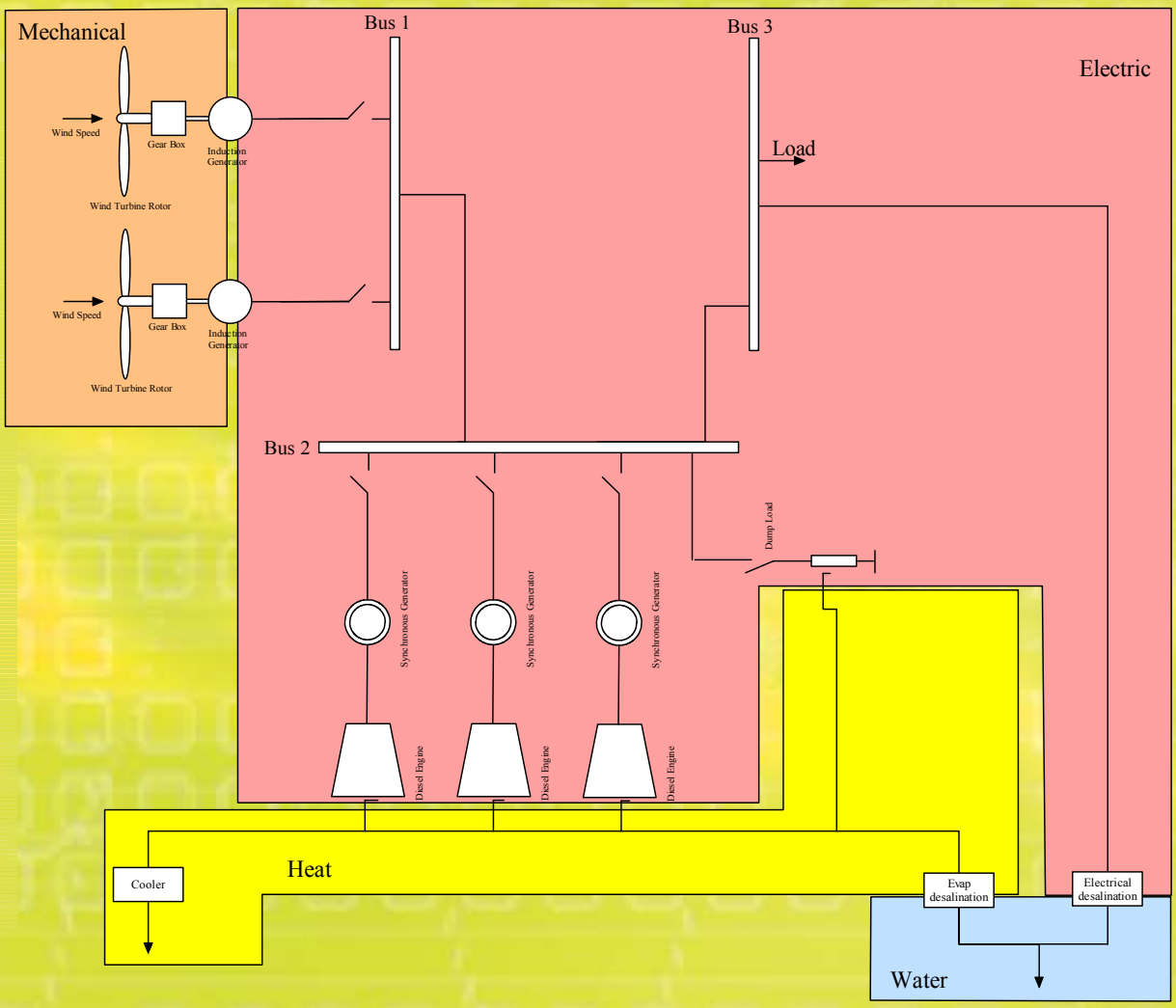
Ver. 1 developed /used in the Gaia project and in EU-Benchmarking of batteries

Battery Lifetime & Performance model under validation – not implemented i IPSYS



# IPSYS Simulation example

- Different domains are explicitly modelled including feedback between them
- Input modelled for each wind turbine load etc.
- Controllers can be exchanged



# IPSYS Summary

- The IPSYS software package is especially developed for simulation of integrated power systems
- Its main features are
  - Detailed modelling of the the electrical network including active and reactive power constrains,
  - Flexible system configuration and controller modelling
  - Modelling of several domains (electric, heat, water)
- It is now ready for being used in real projects

# EFP Gaia stand-alone wind turbine

- Standard Gaia wind turbine as stand-alone
- Back-to-back converter for wind turbine and grid control
- Optional battery in the dc-link
- Controller for system and wind turbine supervisory control
- Prototype controller
  - Turbine control (rotational speed control)
  - Grid control (start up, sync, (f, U))
  - Dynamic unit control (incl. braking resistor and battery)

Main data

- 11 kW
- 2 bladed, diameter 13m
- fixed pitch stall control
- Teeter hub
- Down wind, passive yaw
- Induction generator
- Hub height: 18m

Gaia WT developed as stand-alone

Test & verification completed

Simulation with IPSYS for verification and technical-economical modelling

Report issued – September 2004